Optimisation de l'ordonnancement de workflows basé sur les QoS dans les environnements de Cloud Computing.

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Vichy 2014 -
04 juin 2014

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Outline

Context & Motivations

Problem Description

Proposed Solutions

Experiments

Conclusion & Perspectives

Cloud Computing

- New paradigm.
- SaaS, PaaS, IaaS, HaaS, * as a services.
- Pay-as-you-go model!!
- QoS parameters : SLA (Service Level Agreement)

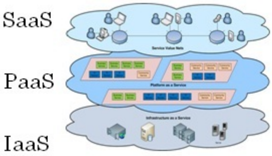

Figure: Cloud Computing Services Offering Models

- Cloud used to run users applications .

Applications

- Scientific workflow:
  bioinformatic, astronomy, ...



- Contain
  - Large number of tasks.
  - Complex data of various sizes.
- Need :
  - High computation power.
  - IT infrastructures availability.
- Require(QoS):
  - Execution time
  - Execution cost
  - Reliability

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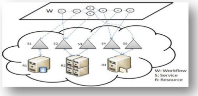
Workflow scheduling

- Workflow scheduling
  Process that maps and manages the execution of interdependent tasks on distributed resources.
- Related works
  Several previous works:
  - time and cost.
  - Reliability, Energy:.
- Contribution
  Extending previous works to handle multiple QoS.



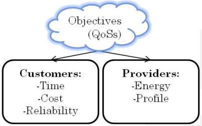


Figure: Conflicting Objectives

- Workflow Scheduling = NP-Complete.

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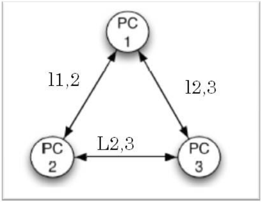
Objectives

- Developing MOO algorithms for QoS-based workflow scheduling in cloud environments.
- The Scheduler:
  - Analyze the users QoS parameters,
  - Map the workflow tasks on resources so that:
  - The execution must be completed,
  - Users QoS constraints must be satisfied,
  - The use of cloud resources must be optimized.

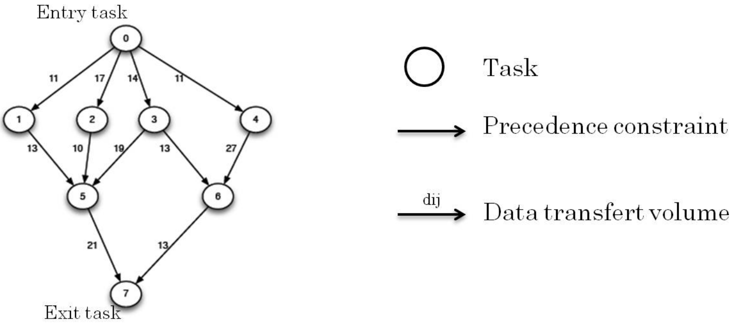
Cloud computing model

- M heterogeneous Virtual Machines (VMs),
- fully interconnected,
- Different processing capabilities,
- Different prices.
- DVFS-enabled in the case of HaaS.



Workflow model

- Workflow = DAG G = (T, E)
  - T : tasks, and E : data dependencies



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QoS parameter models(1/3)

- Time model (makespan)

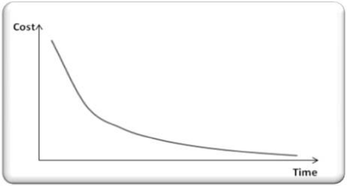
$$T_{total} = \max AFT(T_{exit})$$

- Cost model

$$C_{total} = C_{ex} + C_{tr}$$

$$C_{ex} = \sum_{i=1}^{n} w_i * ec_i$$

$$C_{tr} = \sum_{i=1}^{n} \sum_{j=1}^{n} d_{ij} * trc_{ij}$$



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QoS parameter models (2/3)

- Reliability model

Probability that the workflow will be executed successfully.

$$R_{total} = \exp^{-\sum_{i=1}^{n} \omega_i * \lambda_i}$$

λ_i = failure rate of the VMi .

- Availability model

Average time that the VMs are idles during the workflow execution.

$$A_{total} = \frac{1}{M} \star (1 - \sum_{j=1}^{M} \frac{executionTime_j}{Makespan})$$

M= number of VMs.

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QoS parameter models (3/3)

- Energy model

Derived from the power consumption model in CMOS circuits (DVFS)

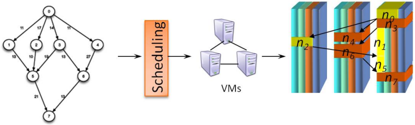
$$E_c = \sum_{i=1}^{n} AC_{ef} * v_i^2 * f_i * wr_i^*$$

- A: switches per clock cycle, C: capacitance load,
- V: supply voltage, f: frequency,
- wr: real completion time of task on the scheduled processor

Higher the frequency level = higher the energy consumption

Scheduling Model

- Construct a mapping M of tasks to VMs
  - Without violating precedence constraints
  - Minimizing the conflicting objectives:
    1. **Makespan**: min $T_{total}(M)$
    2. **Cost:** min $C_{total}(M)$
    3. **Reliability:** max $R_{total}(M)$
    4. **Availability:** max $A_{total}(M)$
    5. **Energy:** min $E_{total}(M)$



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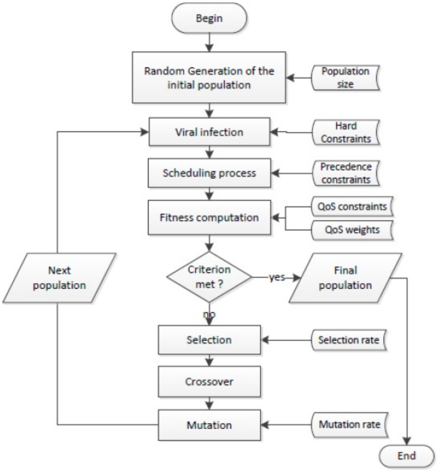
Proposed Solutions

- **GA**: Makespan + Cost + reliabilty + Availability.
- **GAVI**(Viral Infection): Makespan + Cost + reliabilty + Availability + QoS Constraints + hard constraints (Taski-Resourcej)
- **NSGA-II**
- **PAES**
- **DVFS-MODPSO** : Makespan + Cost + Energy.

The Proposed Solution

- The use of **Genetic Algorithms (GA)** is usually efficient to address NP-hard problem.
- Define:
  - A structure encoding a solution.
  - A fitness function.
  - Genetic operators: selection, crossover, mutation

Simplified GA flowchart



Solution encoding

T_1	T_2	T_3	...	T_N
VM_1	VM_3	VM_1	...	VM_3

Fitness function

- n QoS attributes to be minimized.
- m QoS attributes to be maximized.

$$F = \sum_{i=1}^{n} \omega_i \star (\frac{q_i - q_{imin}}{q_{imax} - q_{imin}}) + \sum_{j=1}^{M} \omega_j \star (1 - \frac{q_j - q_{jmin}}{q_{jmax} - q_{min}})$$

- $\omega_i(\omega_j)$: weights for QoS attribute
- $q_{imin}, (q_{imax})$: minimal (maximal) values of the objective i in the current pool of the solutions.

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Fitness function

$$Penalty_i = \begin{cases} \mathrm{Max}\left(1, \left(\frac{QoS_i}{Limit_i}\right)^2\right), & \text{if } QoS_i \text{ to minimize} \\ \mathrm{Max}\left(1, \left(\frac{Limit_i}{QoS_i}\right)^2\right), & \text{if } QoS_i \text{ to maximize} \end{cases}$$

$$Fitness = F * \prod Penalty_i$$

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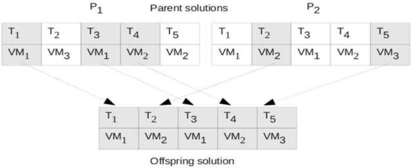
Genetic operators

- **Selection**
  - keep only the top a% solutions.
  - Select parent solutions in the remaining pool.
- **Mutation**
  - Each solution has Y% to be mutated,
  - Change VM associated with the task.
- **Crossover**

$$Ratio = \frac{Fitness_1}{Fitness_1 + Fitness_2}$$



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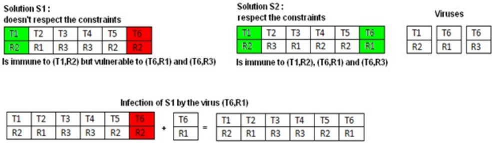
Genetic operators

- **Viral Infection**

- It aims at repairing solutions that do not respect the hard constraints instead of deleting them.
- The idea is to create a virus for each constraint whose type is : Task X must be scheduled on Resource Y.
- After selection, crossover and mutation : every solution that doesnt meet the CSP requirements is infected by the associated virus and repaired.



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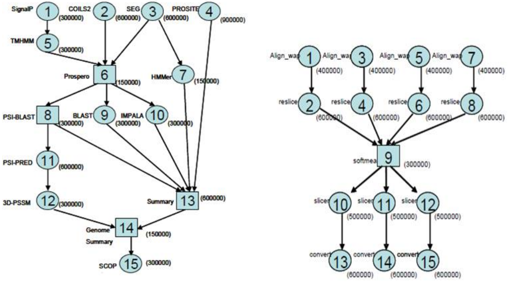
Applications

- Benchmark employed in the simulations:



(a) Hybrid workflow (protein annotation)

(b) Parallel workflow (neuro-science)

Figure: Workflow applications

Cloud

- VM characteristics from Amazon EC2 cloud

	Speed (MIPS)	*Price $/h*	*Failure Rate*
m1.xlarge	5400	0.92	10^{-7}
m2.xlarge	4800	0.57	10^{-7}
m2_2xlarge	8500	1.14	10^{-6}

- Evaluation process:
  - Perform a single-objective optimization.
  - Run our algorithm to get the multi-objectives results of each metric.
  - Compare the values obtained.
  - Vary the weights of the various QoS metrics.
  - Compare our results with those of the HEFT algorithm.

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Results

- Hybrid workflow best values

	Makespan (s)	*Cost ($)*	*Reliability (%)*	*Availability (%)*
HEFT	492.899	2.26875	99.9994895	44.76
B. Makespan	**441.176**	2.3829	99.9995172	35.185
B. Cost	688.235	**1.91176**	99.9993118	66.6667
B. Reliability	616.349	2.50272	**99.999624**	51.2732
B. Availability	456.738	2.50511	99.9995763	**34.1826**
Overall best values	**441.176**	**1.91176**	**99.999624**	**34.1826**

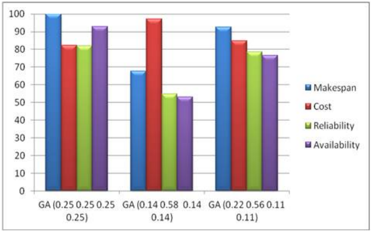
- Parallel workflow best values

	Makespan (s)	*Cost ($)*	*Reliability (%)*	*Availability (%)*
HEFT	541.176	3.14293	99.9993998	30.309
B. Makespan	**481.612**	3.25549	99.9994593	18.8851
B. Cost	894.118	**2.48366**	99.9991059	66.6667
B. Reliability	962.963	3.45921	**99.9996214**	56.8929
B. Availability	481.612	3.25549	99.9994593	**18.8851**
Overall best values	**481.612**	**2.48366**	**99.9996214**	**18.8851**

Results

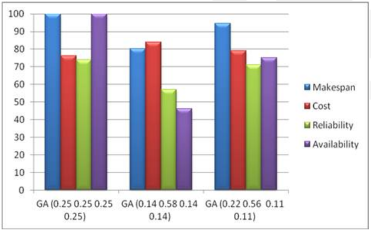
- Hybrid workflow results

Hybrid	*Makes-pan (s)*	*Cost ($)*	*Reliability (%)*	*Availability (%)*
GA (0.25 0.25 0.25 0.25)	441.176	2.32503	99.999511	36.7593
GA (0.14 0.58 0.14 0.14)	652.941	1.96805	99.999342	64.3083
GA (0.22 0.56 0.11 0.11)	**476.471**	**2.24946**	**99.999490**	**44.70**
Overall best values	441.176	1.91176	99.999624	34.1826
HEFT	**492.899**	**2.26875**	**99.9994895**	**44.76**



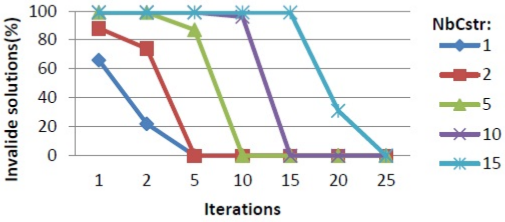
- Parallel workflow results

Parallel	*Makes-pan (s)*	*Cost ($)*	*Reliability (%)*	*Availability (%)*
GA (0.25 0.25 0.25 0.25)	481.612	3.25549	99.999459	18.8851
GA (0.14 0.58 0.14 0.14)	600	2.95267	99.999354	40.9465
GA (0.22 0.56 0.11 0.11)	**509.807**	**3.13839**	**99.999441**	**25.1625**
Overall Best values	481.612	2.48366	99.9996214	18.8851
HEFT	**541.176**	**3.14293**	**99.9993998**	**30.309**



Results

- Compare GAVI with GA by assessing the number of invalid solutions.



- Experiment run on the two 15 tasks workflows using different numbers of constraints and a pool of 3 resources : The efficiency of the classical genetic algorithm without viral infection plummet as the number of constraints increases.

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Results

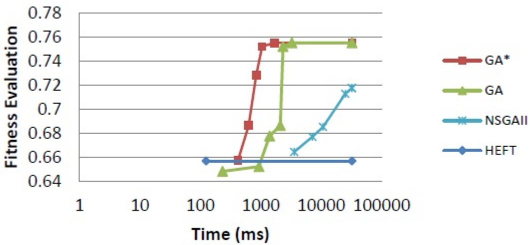
- Interest of the proposed penalty method when adding constraints on the QoS

Algo.	Constraints	Makespan (s)	Cost ($)	Reliability
GA*	time<=500	**481.612**	3.25549	0.999995
		479.532	3.28068	0.999995
GA*	Cost<=2.5	894.118	**2.48366**	0.999992
GA*	reliability>=0.999997	666.667	3.788806	**0.999997**
GA*	time<=550,cost<=3.2	**529.412**	**3.12954**	0.99.9994

- Results of the QoS constrained optimization on the parallel workflow

Results

- comparing with other algorithms



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Conclusions

- We have investigated the QoS based scheduling problem on scalable computing systems
- We proposed GA for workflow scheduling
  - A new fitness function model which can takes into account a great number of users and providers QoS requirements specified in the SLA.
- The proposed solution outperforms related approaches .

Perspectives

- We plan to implement our algorithms in workflow management systems (Cloudbus).
- Explore other meta-heuristics (e.g.,PSO+Tabu, ACO, SA)
- Consider other QoS metrics: Security,
- Parallelization

Publications(1/3)

- Journals:
  1. S. Yassa, J. Sublime, R. Chelouah, H. Kadima, G-S. Jo, B. Granado, A Genetic Algorithm for Multi-Objective Optimization in Workflow Scheduling with Hard Constraints, International Journal of Metaheuristics, 2013 Vol.2, No.4, pp.415 - 433
  2. S. Yassa, R. Chelouah, H. Kadima, B. Granado, Multi-Objective Approach for Energy-Aware Workflow Scheduling in Cloud Computing, The Scientific World Journal, vol. 2013, Article ID 350934, 13 pages, 2013. doi:10.1155/2013/350934

Publications(2/3)

- Conferences:
  1. S. Yassa, R. Chelouah, H. Kadima, B. Granado, A Genetic Algorithm Approach to QoS based Workflow Scheduling in Cloud computing Environment, Proceeding of ICDSD'12 International Conference en Distributed Systems and Decisions, ISSN 2335-1012, Oran-Algeria, November 21-22, 2012.
  2. J. Sublime, S. Yassa, G-S. Jo, A genetic algorithm with the concept of viral infections to solve hard constraints in workflow scheduling, In proceeding of: Korea Intelligent Information System Society, At Seoul National University, Seoul, p95-100, 2012

Publications(3/3)

- EURO Conferences:
  1. S. Yassa, R. Chellouh, H. Kadima, B. Granado, A Genetic Algorithm Approach to a Cloud Workflow Scheduling Problem with Multi-QoS Requirements, 26th European Conference on Operational Research, Rome 1-4 july, 2013
  2. S. Yassa, R. Chelouah, H. Kadima, B. Granado, A PSO-based Heuristic for energy-aware scheduling of Workflow applications on cloud computing, 25th European Conference on Operational Research, Lithuania 2012.
- workshops:
  1. S. Yassa, H. Kadima, Ngociation et composition dynamique des services base sur le SLA dans un Cloud, Workshop sur l'Evolution du principe de Rutilisation entre Composants, Services et Cloud Services(RCS2), juin 2011, Lille

Thank you

Are there any

- Questions?
- Comments & Suggestions